

Interactive comment on “Estimating the maritime component of aerosol optical depth and its dependency on surface wind speed using MODIS and QuikSCAT data” by Y. Lehahn et al.

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We are thankful to the reviewer for his or her assessment of the manuscript. Following the reviewers' useful suggestions we have added a detailed discussion on the dataset limitations as well as on the sensitivity of the methodology and results to the accuracy of the measurements.

Below we address all the reviewers' comments one by one.

1) This study estimates the maritime component of aerosol optical depth (AOD) and suggests a dependence of maritime component AOD on surface wind speed. The idea and the employed methodology are interesting and clearly presented. The analysis

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benefits the global character of satellite observation, however it has to face limitations of retrieval accuracy. The authors make an effort and examine their methodology for 1) possible dust "contamination" (comparison of MODIS derived AOD coarse fraction and QuikSCAT derived wind speed in a region affected by dust), and 2) possible uncertainty in satellite retrievals (comparison with ground-based measurements in the Midway Island AERONET site).

1) answer: We thank the reviewer for acknowledging the efforts made for insuring the quality of our analysis.

2) However, low values of marine aerosol optical depth, which are on the level of MODIS accuracy, invite more attention to possible influence of data accuracy.

2) answer: We acknowledge that more emphasis should be given to discussing the limitations and accuracy of the MODIS retrievals. This point is corrected in the revised manuscript, by adding the following paragraph to section 2.1.1 "Aerosol properties" (page 05, lines 24-25 and page 06, lines 01-20):

"MODIS over-ocean aerosol retrievals can be disrupted by a number of factors including cloud contamination (Kaufman et al., 2005, Zhang et al., 2005), and sea surface reflectance by sun glint (Cox and Munk, 1954) and whitecaps (Moore et al., 2000). The latter, which is directly linked to the surface wind speed, may lead to systematic biases in the MODIS over-ocean aerosol retrievals that assume a constant wind speed of 6m/s for estimating reflectance from the sea surface (Zhang and Reid, 2006). The different factors influencing MODIS over-ocean retrievals of τ and ff are especially important in low aerosol loading conditions (e.g., $\tau < 0.1$, Kleidman et al., 2005), where MODIS is less sensitive to aerosol characteristics and the accuracy of the retrieval decreases. While the validation of MODIS over-ocean τ also includes comparison with AERONET measurements at low aerosol loading conditions, resulting in a remarkably good agreement, with an estimated uncertainty of $0.03 \pm 0.05 \tau$, validation of ff is still limited to higher τ conditions (e.g., Kleidman, 2005). Nevertheless, recent results from

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Yu et al., (2009), showing remarkable consistency between seasonal and geographical variations in pure marine aerosol (defined by the authors as $0.03 < \tau < 0.10$) ff from MODIS and from two chemical model simulations, indicate that over-ocean MODIS retrievals provide a reliable estimates of ff even in very low aerosol loading condition. This supports Remer et al., (2008) conclusion that over-ocean MODIS ff can be considered as a tested, well-understood product that delivers a quantitative measure of aerosol particle size. In order to avoid biases in aerosol retrievals resulting from cloud contamination effects, all data associated with $\tau > 0.7$ was excluded from the analysis.”.

3) Also, the accuracy of the QuikSCAT derived wind speed and its possible influence have to be mentioned.

3) answer: We acknowledge that a discussion on the accuracy of the wind retrievals is missing. Such a discussion is added to the revised manuscript. In addition, the revised manuscript includes an extended analysis of wind speed measurements by using the data of two additional sensors (AMSR-E and SSM/I), that use different measuring techniques. The following paragraph describing the wind sensors is now found in section 2.1.2 (page 07, lines 05-15) of the revised manuscript: “The three wind sensors used in this research differ in their measuring methods and wind products. While QuikSCAT (Spencer et al., 2000) is an active scatterometer that uses microwave radar for measuring vector winds (i.e. speeds and directions), AMSR-E (Wentz et al., 1999) and SSM/I (Wentz et al., 1997) are passive microwave radiometers that provide estimates of scalar wind speeds (without directions). Estimates of W from both passive radiometers and active scatterometers were validated against buoy data (e.g., Ebuchi et al., 2002, Mears et al., 2001), and, despite the differences in measuring methods, show good agreement between them (Wentz et al., 2007). In order to avoid errors resulting from rain effects on scatterometer wind retrieval (Weissman et al., 2002) rain flags were used to identify and mask rainy pixels in the QuikSCAT data (AMSR-E and SSM/I do not retrieve winds in rain).”

4) A discussion on estimation of sensitivity of the presented results and methodology

to uncertainties in MODIS and QuikSCAT data has to be added.

4) answer: In order to have better estimation of our datasets we extended them to include measurements of additional sensors, MODIS-Aqua for AOD measurements and AMSR-E and SSM/I for winds. The wind sensors use different measurement methods and the comparison between them is very helpful in terms of validation. We acknowledge that a discussion on the sensitivity of the results and methodology to uncertainties associated with the dataset was missing in the previous version. This is corrected in the revised manuscript, by adding the following section (4.1.) entitled “Limitations and uncertainties” (page 13, lines 04-25 and page 14, line 01):

“The dataset used in this study is well validated against in-situ measurements from buoys (for surface wind speeds) and AERONET stations (for aerosol retrievals). Nevertheless, the suggested methodology and consequent results should be considered in view of uncertainties associated with the satellite data. Since this study is focused on linking marine aerosols and W , our main concern is with unaccounted for wind effects that may lead to underestimates of τ at low wind cases and overestimates at high winds (Zhang and Reid, 2006). This uncertainty is significantly reduced when comparing the relationship between W and aerosol retrievals from MODIS to that of W and ground based aerosol measurements from AERONET station in Midway Island (Sec. 2.5). The reliability of the satellite derived $W - \tau_m$ relationship found here is also strongly supported by the good agreement with the studies of Smirnov et al. (2003) and Mulcahy et al. (2008), which are also based on ground measurements and are thus not affected by reflectance from the sea surface (Fig. 5a).

Further reduction of the uncertainty associated with aerosol retrieval accuracy is achieved by avoiding the “roaring forties” region, where the effect of cloud contamination and retrieval biases due to wind effects are considered to be especially important (Zhang et al., 2005; Zhang and Reid, 2006). In addition, we note that with τ_0 , which is constant in nature, having an averaged value of approximately 0.08 (Fig. 5a), most of the wind related variability is associated with $\tau > 0.1$, thus not included in the some-

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what problematic category of very low aerosol loading conditions. Finally, the reliability of the results, which show a remarkable consistency through various locations over the World's ocean, is supported by the use a very large dataset that covers a large variety of oceanic and atmospheric regimes throughout a relatively long (6 years) time span, hence including a wide range of wind speeds and aerosol properties. ”.

5) Also, I would suggest indicating the literature values of the slopes AOD vs. wind speed (data superimposed in figure 6, Smirnov et al; Huang et al). This also could be helpful for comparison and strength the presented results.

5) answer: We agree that such addition will contribute to the quality of the work, and the literature values are included in the revised manuscript.

6) Besides, the presented methodology and the obtained results show consistency, agree with other studies and after addressing the mentioned above issues will be valuable for the community and worth of publication.

6) answer: We thank the reviewer for his or her supporting statement about the quality and value of the manuscript.

Other comments

1) Number 3 in Summary and conclusions: I would suggest indicating the value for "threshold wind" for dust emission along with the value for triggering emission of maritime aerosol. It can be an interesting comparison.

1) answer: After re-evaluation of our results through the review process, we now find the conclusion on the threshold wind speed to be not sufficiently robust, and it therefore not included in the revised manuscript.

2) Page 1986: "...is possible by the spectral dependence that is linked to the aerosol size..." Spectral dependence of AOD, I guess? It is missing in the text.

2) answer: This point is clarified in the revised manuscript.

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3) There is also a typo on page 1992: "...linking W with tauc and tauc...", I guess it should be "...tau and tauc...".

3) answer: The typo is corrected in the revised manuscript.

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